

# **Introduction to Natural Hazards**

## **Chapter 1**

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# Framework for Each Chapter

- Learn the Objectives of the Chapter
  - Introduction to each hazard
  - Examine the processes of the hazard
  - The cycle of the hazard
  - Geographic regions at risk of this hazard
  - Natural functions of the hazard
  - Human interaction with the hazard
  - Minimizing the risk of the hazard
  - Looking at the Perception of and Adjustments to the risks of the hazard
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# Learning Objectives

1. Learn the difference between a disaster and a catastrophe
  2. Learn the components and processes of the geologic cycle
  3. Understand the scientific method
  4. Understand the basics of risk assessment
  5. Recognize natural hazards that cause disasters are generally high energy events caused by natural earth processes
  6. Understand the concept that the magnitude of a hazardous event is inversely related to its frequency
  7. Understand how natural hazards may be linked to one another and to the physical environment
  8. Recognize that increasing human population and poor land-use practices compound the effects of natural disasters and catastrophes
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# Why Study Natural Hazards?

- To learn about the internal and external forces of the earth and how they interact with civilization
  - To learn how civilization can better adjust and adapt to these forces
  - To learn to appreciate and respect the awe of these processes and their effects
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# Processes: Internal and External

- Process – the physical, chemical, and biological ways by which events effect the earth's surface.
    - Internal
      - Tectonic
        - Volcanic eruptions
        - Earthquakes
    - External
      - Climate and Weather – Part of the Hydrological Cycle
        - Hurricanes and Tornados
      - Mass Wasting of the Earth's Surface
        - Landslides
        - Flooding
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# Hazard, Disaster, or Catastrophe

- Natural Hazards

- A natural Process and/or Event that is a potential threat to human life and property.
    - The Event is not the problem, but the danger to humans and their property determines if the Event is to be a Hazard.
    - Affects millions of people around the world
      - ✓ Blizzards and Ice Storms
      - ✓ Wildfires
      - ✓ Tsunamis
      - ✓ Droughts
      - ✓ Subsidence
      - ✓ Coastal erosions
      - ✓ Impacts from asteroids and comets
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# Disasters

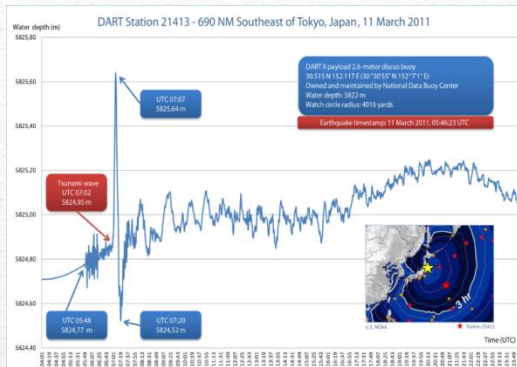
- A Disaster
    - A Hazardous Event that occurs over a limited time span in a defined area
      - Criteria:
        - ❖ Ten or more people killed
        - ❖ 100 or more people affected
        - ❖ A state of emergency is declared
        - ❖ International assistance is requested
    - During past few decades, natural disasters have killed several million people, average loss of life about 80,000 people.
    - Financial loss – exceeds \$50 Billion a year.
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# Catastrophes

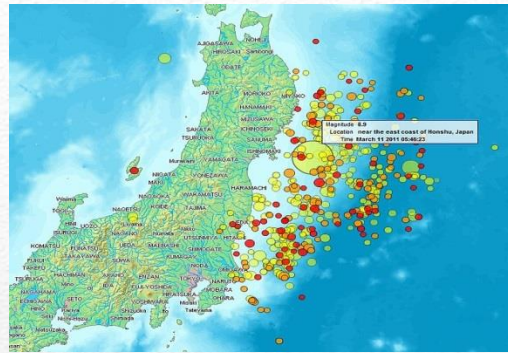
- Catastrophe

- A massive disaster that requires significant expenditure of money and long time recovery to take place.
  - Some of the most current Catastrophes are:
    - ✓ Hurricane Katrina - 2005
    - ✓ Haiti Earthquake -
    - ✓ Indonesia Earthquake and Tsunami -2004
    - ✓ Bangladesh Hurricane - 1991
    - ✓ Japan Earthquake and Tsunami- 2011
    - ✓ Northeaster and Hurricane Sandy Combination - 2012
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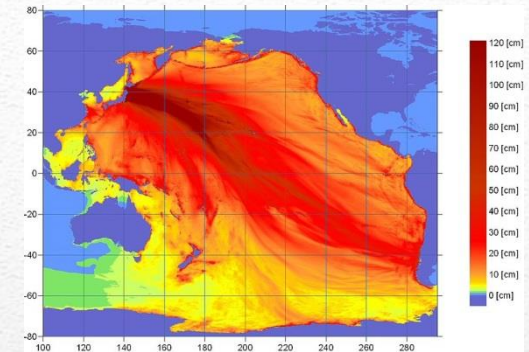




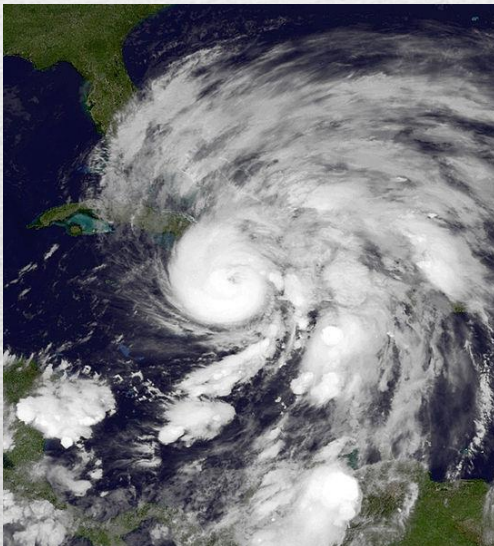
Seismic reading of 9.0 Earthquake



Preceding earthquakes



Tsunami path



Sandy in the beginning



Sandy and the Northeaster



West Virginia snow from Sandy



# DEATHS AND DAMAGE CAUSED BY NATURAL HAZARDS

- To compare the effects of various natural hazards, we look at the greatest loss of life.
  - Next we look at the property damage
    - ❖ How much was the cost
    - ❖ How many people does this damage effect
    - ❖ The most important to look at is the potential to produce a catastrophe.
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# Which Hazards Could Cause Catastrophes

- High risk hazards
    - Floods
    - Hurricanes
    - Tornadoes
    - Earthquakes
    - Volcanic Eruptions
    - Large Wildfires
    - Heat Waves
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# Which Hazards Could Cause Catastrophes

- Moderate and low risk hazards
    - Landslides (effect a smaller area)
    - Drought
    - Coastal Erosion
    - Frost
    - Lightening
    - Expansive Soils
    - Extra Terrestrial impact
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# Understanding Hazards Through History

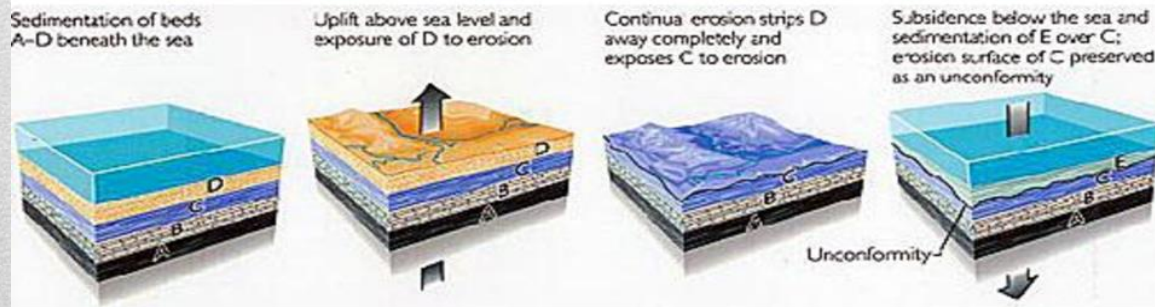
- Natural Hazards are repetitive through history
  - By studying the history of natural hazard events, we can gain information for a hazard-reduction plan.
    - Some of these plans are
      - Better building requirements (for earthquakes and floods)
      - Where are natural flood plains
      - Understand the land for potential landslides
    - To totally understand Nature and all its hazards, we must study and understand information to gain a background of the natural processes of the earth
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# Geologic Cycle

- The Geologic conditions and materials largely govern the type, location, and intensity of natural processes.
- An understanding of the components and dynamics of the geologic cycle will explain these relationships

## The Geologic Cycle

3 stages: uplift, erosion, deposition





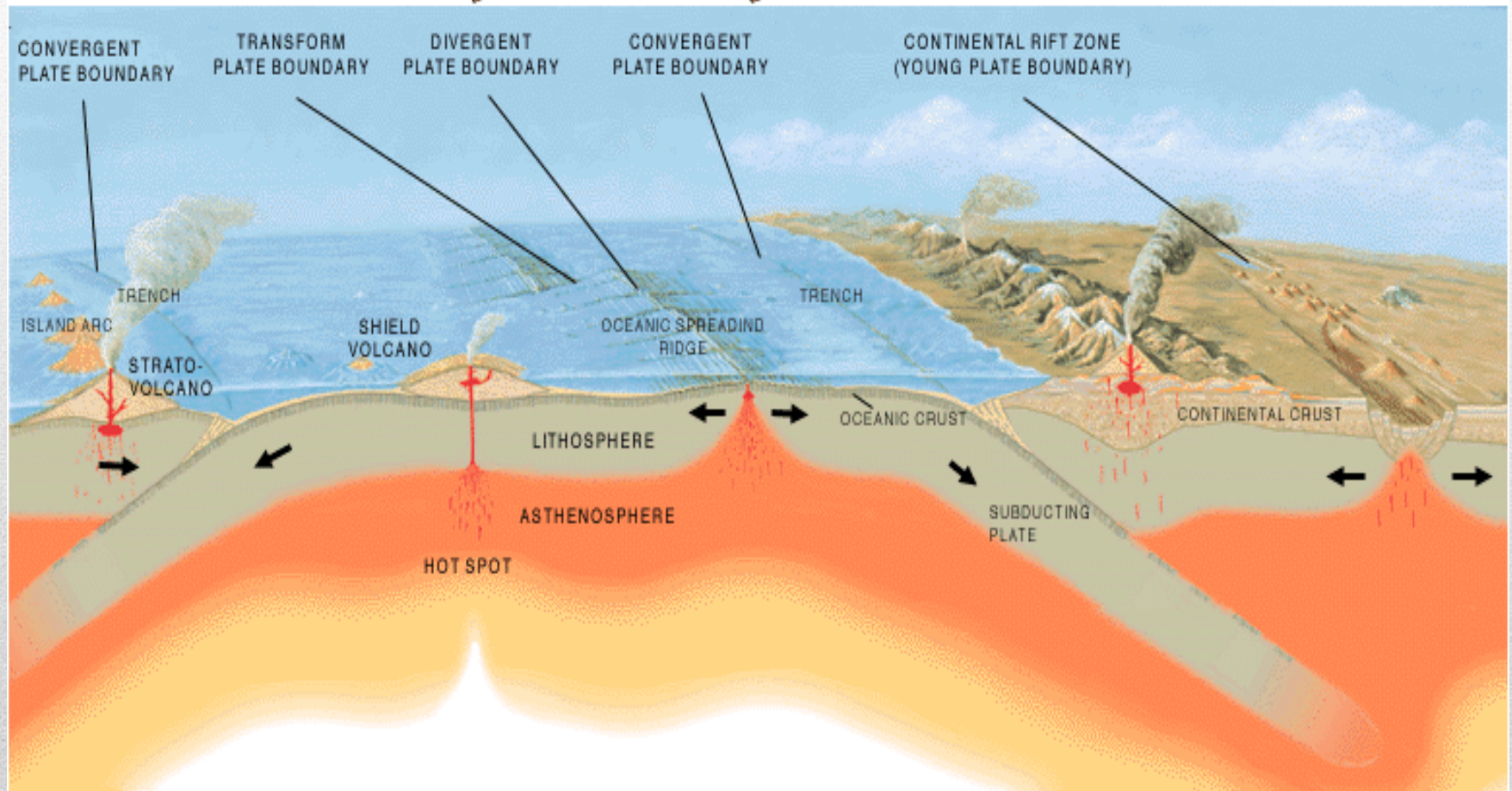
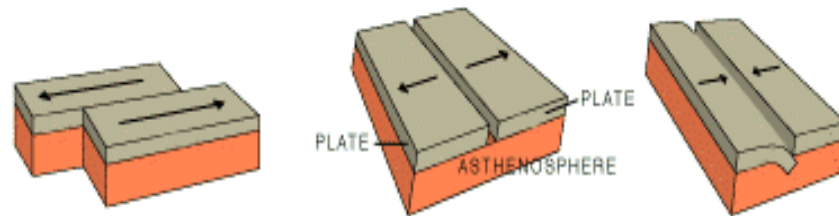
# Geologic Cycle

- **What describes the Geologic Cycle**
    - Throughout the 4.6 billion years of the Earth's history materials on or near the earth's surface have been created, maintained, and destroyed by numerous physical, chemical, and biological processes.
    - These processes produce earth materials, land, water, and atmosphere, necessary for our survival.
    - These processes are called the **geologic cycle** made up of
      - **The Tectonic Cycle**
      - **The Rock Cycle**
      - **The Hydrology Cycle**
      - **The Biogeochemical Cycle**
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# Tectonic Cycle

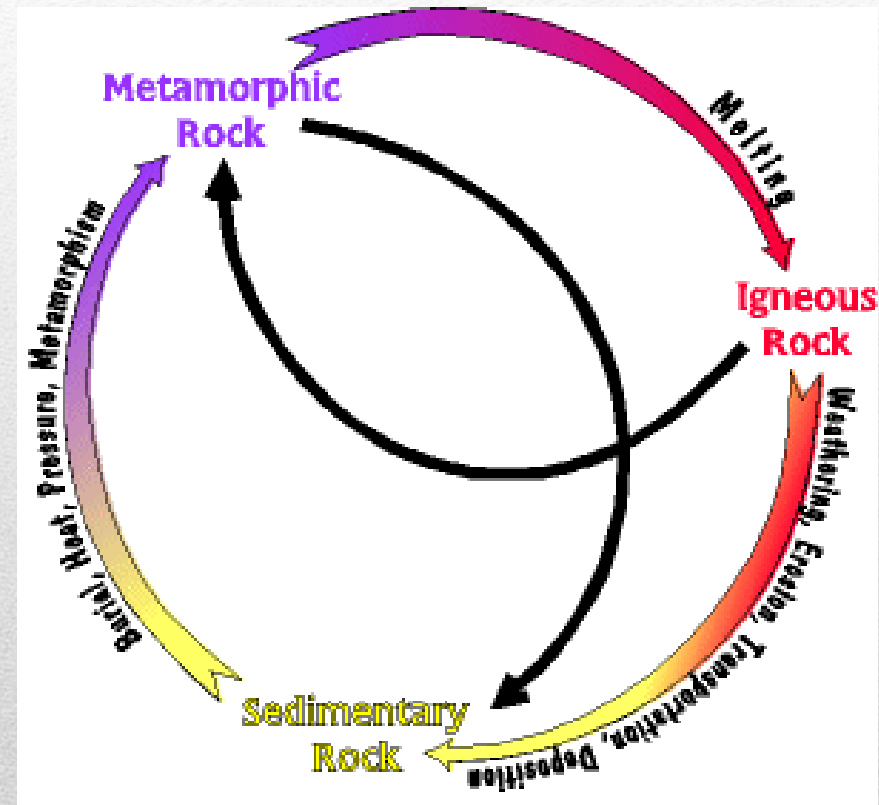
- **Tectonic** refers to the large-scale geologic processes that form and deform the Earth's crust and produce landforms such as ocean basins, and continents, and mountains
  - The **Tectonic cycle** involves the creation, movement, and destruction of these tectonic plates.
  - It is responsible for the production and distribution of rock and mineral resources invaluable to modern civilization, as well as hazards such as volcanoes and earthquakes.
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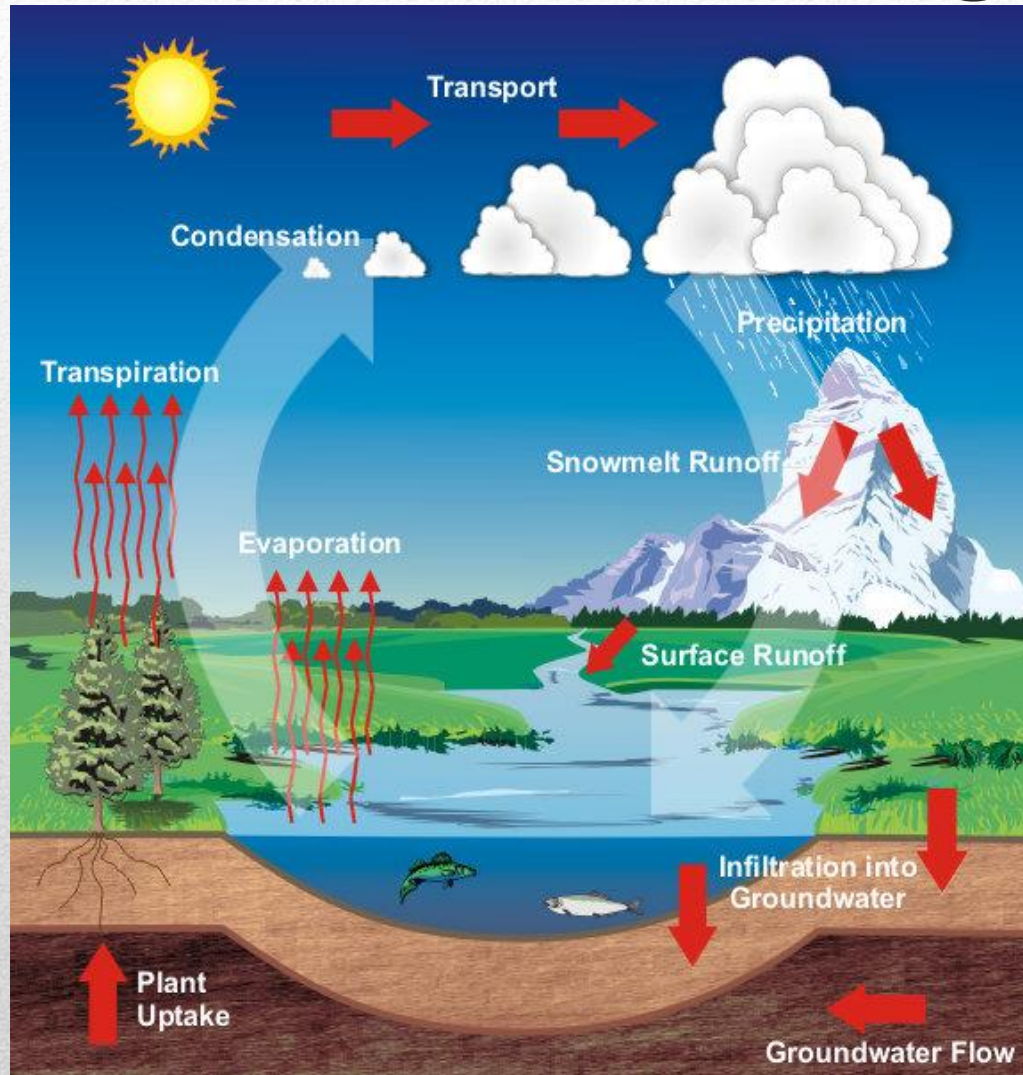
# Rock Cycle

- Rock Cycle
  - Rocks are aggregates of one or more *minerals*.
  - It is the largest geologic subcycle and it is linked to all the other subcycles
    - Depends on:
      - ❖ The tectonic cycle for heat and energy
      - ❖ The biogeochemical cycle for materials
      - ❖ The hydrologic cycle for water.





# Hydrologic Cycle



- Hydrologic Cycle
  - Water Vapor in the air, returns to the earth through precipitation, from the earth through streams, ground water and evaporation or evapotranspiration returns to the oceans and the air to start again.



# Biogeochemical Cycles

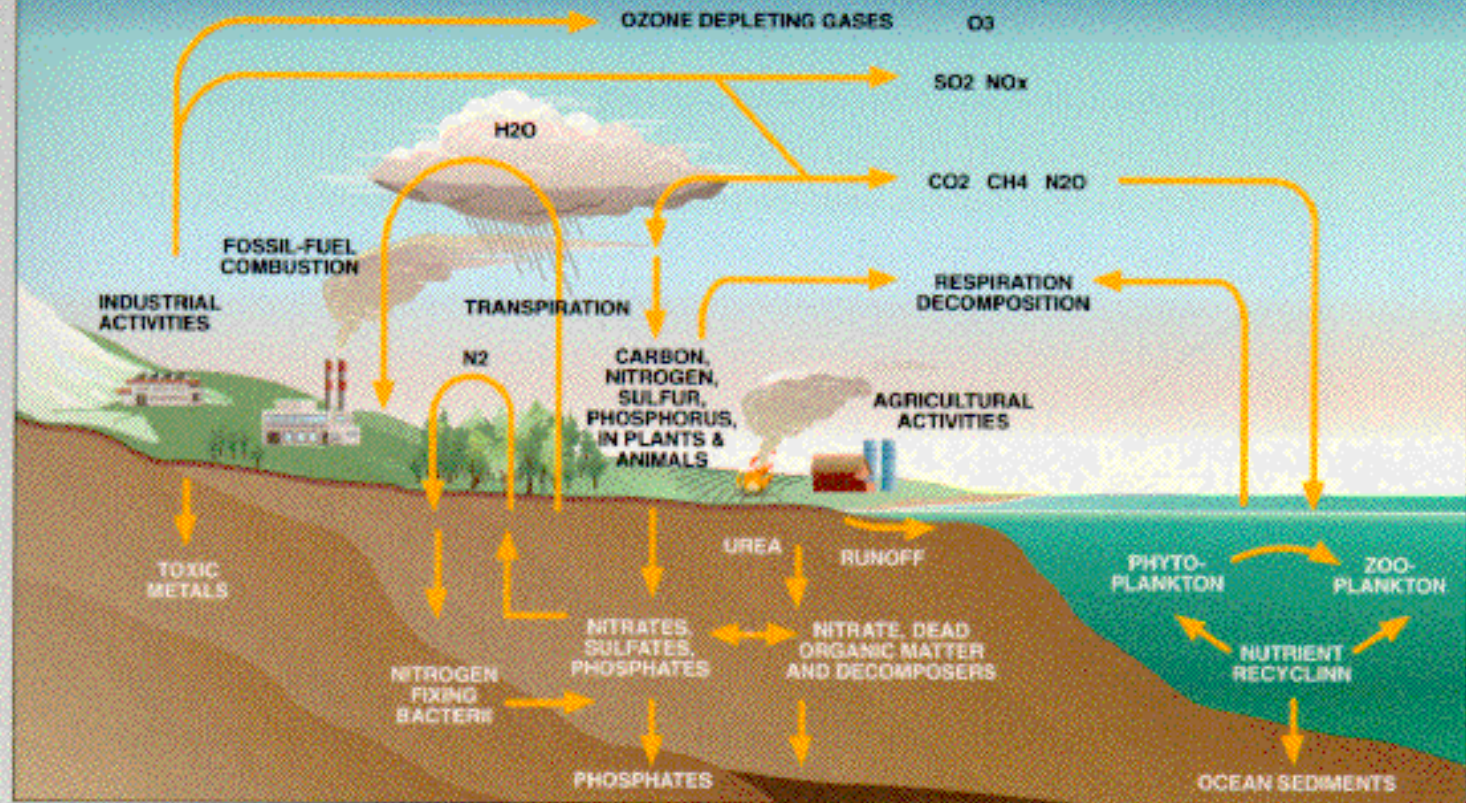
- The transfer or cycling of a chemical element or elements through the atmosphere, lithosphere, hydrosphere, and biosphere
- The tectonic cycle provides water from volcanic processes as well as heat and energy used to for and change the earth materials
- The rock and hydrologic cycles are involved in many processes that transfer and store chemical in water, soil and rock.
- Biogeochemical cycles can most easily be described as the transfer of chemical elements through a series of storage compartments or reservoirs

❖ Air, Soil, Groundwater and Vegetations

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# BIOGEOCHEMICAL PROCESSES





# Fundamental Concepts for Understanding Natural Processes as Hazards

- Five Basic Concepts to Understanding Natural Hazards
    1. Hazards are predictable from scientific evaluation
    2. Risk analysis is an important component in understanding the effects of hazardous processes
    3. Linkages exists between different natural hazards as well as between hazards and the physical environment
    4. Hazardous events that previously produced disasters are now producing catastrophes
    5. Consequences of hazards can be minimized
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# Concept: 1

## **Hazards are Predictable from Scientific Evaluation**

- Science and Natural Hazards
    - Use of the Scientific Method
      - Formulate a question
      - Develop a hypothesis
      - Test the hypothesis with experiments
    - From the results of the experiments, develop a conclusion
  - Use Scientific Method to understand and develop a predict natural hazards
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# SCIENTIFIC METHOD

## PURPOSE

State the problem.

## RESEARCH

Find out about the topic.

## HYPOTHESIS

Predict the outcome to the problem.

## EXPERIMENT

Develop a procedure to test the hypothesis.

## ANALYSIS

Record the results of the experiment.

## CONCLUSION

Compare the hypothesis to the experiment's conclusion.



# Hazards are Predictable from Scientific Evaluation

- Hazards are Natural Processes

- Modern humans seem to be a product of the Pleistocene ice age of 1.8 million years ago
    - There has been rapid climate change from harsh glacial conditions to a few thousand years ago when the climate began to warm.
    - We had to learn to “adapt and overcome” these climate changes in order to survive.
  - Events we call Natural Hazards are Natural Earth processes
  - These natural processes only become Hazards when they happen where people are
  - They also become Hazards when we humans change the land-use by urbanization or by deforestation.
  - We, as humans, should realize these hazards, and try to stay out of the way
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# Geologic Time

- Earth is about 4.6 billion years old
  - Age of the dinosaurs 160 million years ago
  - Rocky Mountains uplifted 65 million years ago
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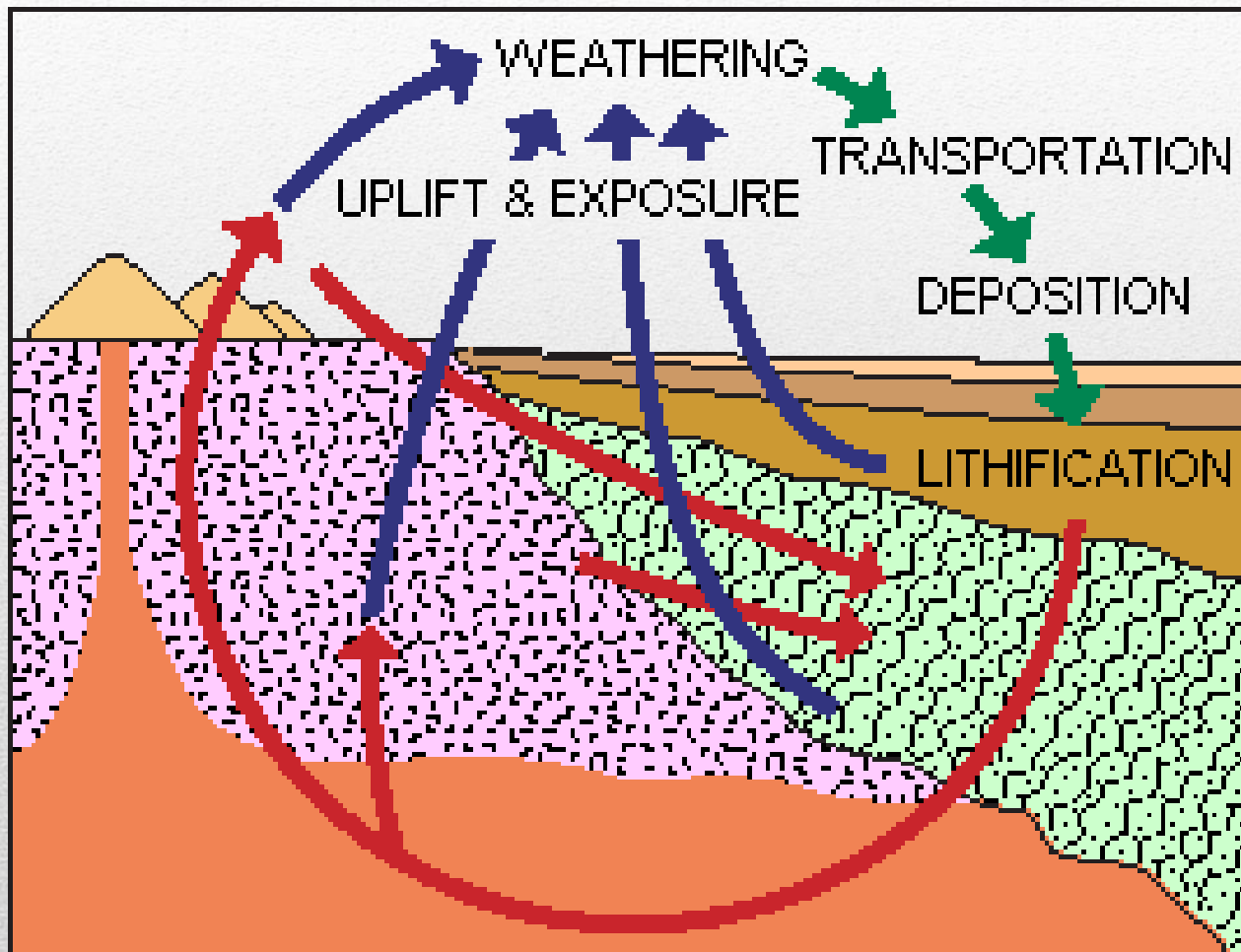
EON	ERA	PERIOD	EPOCH	Ma
Phanerozoic	Cenozoic	Quaternary	Holocene	0.01 —
			Pleistocene	0.8 —
		Tertiary	Late	1.8 —
			Pliocene	3.6 —
			Early	5.3 —
			Late	11.2 —
			Miocene	16.4 —
			Early	23.7 —
			Oligocene	28.5 —
			Late	33.7 —
			Early	41.3 —
		Paleogene	Eocene	49.0 —
			Early	54.8 —
			Late	61.0 —
			Paleocene	65.0 —
			Early	
	Mesozoic	Cretaceous	Late	99.0 —
			Early	144 —
		Jurassic	Late	159 —
			Middle	180 —
			Early	206 —
		Triassic	Late	227 —
			Middle	242 —
			Early	248 —
		Permian	Late	256 —
			Early	290 —
	Paleozoic	Pennsylvanian		323 —
		Mississippian		354 —
		Devonian	Late	370 —
			Middle	391 —
			Early	417 —
		Silurian	Late	423 —
			Early	443 —
		Ordovician	Late	458 —
			Middle	470 —
			Early	490 —
		Cambrian	D	500 —
			C	512 —
			B	520 —
			A	543 —
Precambrian	Proterozoic	Late		900 —
		Middle		1600 —
		Early		2500 —
	Archean	Late		3000 —
		Middle		3400 —
		Early		3800? —

# Forecast, Prediction, and Warning

- Predicting Changes in the Earth System
    - Uniformitarianism: “*the present is the key to the past.*”
      - The fundamental concept of earth sciences, as the earth processes wear down the earth’s surface, the earth processes builds the surface back up
      - Human activities effect these changes
    - Now we have to look at “*the present is the key to the future.*”
  - Environmental Unity-one action causes others in a chain of actions and events
    - “Removal of vegetation on a steep hillsides can bring on landslides in a rain storm”
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# Uniformitarianism



# Forecast, Prediction, and Warning

- **Prediction** involves specifying the date, time, and size of a hazardous event
    - Different from predicting where or how often a particular event will occur
  - A **forecast** has a range of certainty. This involves a percentage of certainty that an event will happen.
    - By giving a forecast of an event, the loss of life can be minimized and there will be less property damage
  - Study of natural hazards helps in the improvement in **forecasting** when the events will happen
  - By knowing the probability and the possible consequences of an event, we can assess the risk of that event and give **warnings**
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# Forecast, Prediction, and Warning

- Minimizing the effects of a hazardous events by:
    1. Identifying the location where a hazardous event is likely to occur
    2. Determining the probability that an event of a given magnitude will occur
    3. Observing any precursor events
    4. Forecasting or predicting the event
    5. Warning the public
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# Forecast, Prediction, and Warning

## 1. Location

Mapping the kind of hazardous events and where they might happen around the world

## 2. Probability of Occurrence

Determine the probability of a particular event in a particular location within a particular time span

## 3. Precursor Events

Many hazardous events are preceded by *precursor events*

## 4. Forecast

When a forecast of an event is issued, the certainty is given in a percentage of an event happening

## 5. Predication

Using the four preceding methods, a prediction can be made that an event will happen

## 6. Warning

Information of the possibility of a hazardous event happening

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# Concept 2:

## Risk Analysis: Understanding the Effects of Hazardous Processes

- Risk of a particular event
    - The product of the probability of that event occurring the times the consequences should it occur.
    - Consequences may be expressed on a variety of scales
  - Determining *acceptable risk* is complicated. This depends on the situation.
    - Governments may require a person to get flood insurance if there is a high risk of flooding in the area that live
    - Individuals can choose where they live if there is a possibility of flooding, earthquakes, hurricanes and even a volcano eruption
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# Concept 3: Linkages

- Connections exist between Natural Hazards and Hazards and the Physical Environment
  - These are called **Linkages**
    - Volcanic eruptions on land are linked to mudflows and floods
    - Eruptions in the ocean are linked to tsunamis
  - **Natural hazards are linked to earth materials**
    - Exposures of shale to landslides
    - Granite to large fractures of rock
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## Concept 4:

# **Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes**

- As the earth's population has increased, natural hazards that once caused disasters, now cause catastrophes
  - This population was soon civilized, lived closer together and built large cities. As this happened a disaster becomes a catastrophe.
  - Example: Mexico City built on an ancient lake bed, in September of 1985 experienced a magnitude 8.0 earthquake, killing 10,000 people.
  - Example: Japan's earthquake and tsunami in 2011. Magnitude 9.0, 10 meter high tsunami waves, 16,000 killed
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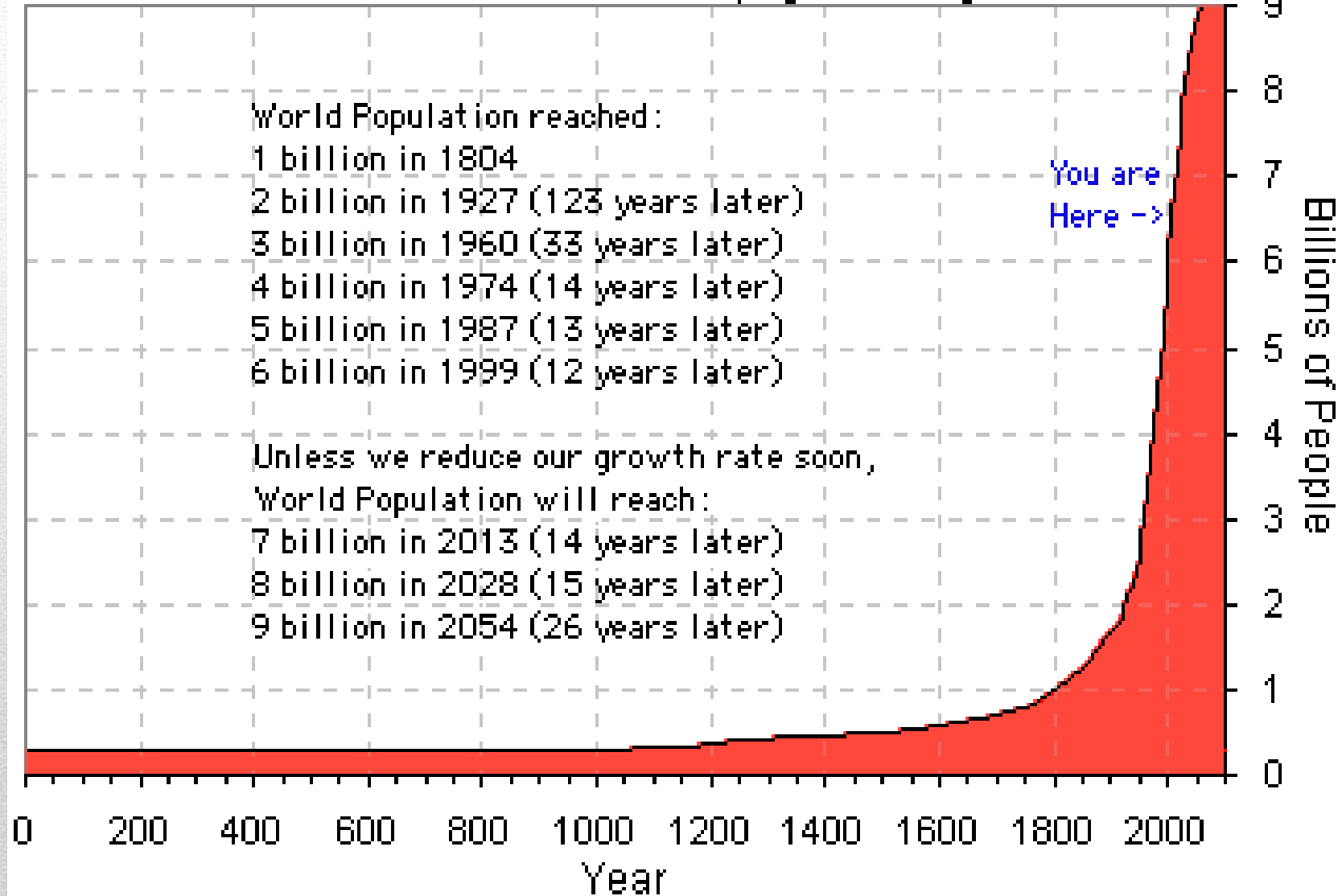


# Concept 4:

## **Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes**

- Increase in the population growth
    - Between 1830 to 1930 – 100 years, the world population increased from 1 to 2 billion
    - Between 1930 to 1970 – 40 years, the world population increased to 4 billion
    - Between 1970 to 2000 – 30 years, the world population increased to 6 billion
    - And from 2000 to July 1, 2013 – 12 ½ years, the world population increased to 7.16 billion people
  - This is why, if a **natural hazard does occur, it most likely will either be a disaster or most likely a catastrophe**
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Source: United Nations, Population Prospects: 2004 Revision





# Concept 4:

## Hazardous Events that Previously Produced Disasters are Now Producing Catastrophes

- **Magnitude and Frequency of Hazardous Events**
  - The *impact* of a hazardous event is in part a function of the amount of energy release, that is the **magnitude** and the interval between occurrences, its **frequency**.
  - The *impact* is also influenced by other factors including:
    - Climate
    - Geology
    - Vegetation
    - Population
    - Land-use
  - Learning to look at these and other factors on natural hazards may lessen these impacts on the **rising population**.

# Concept 5:

## Consequences of Hazards Can Be Minimized

- Many times we deal with natural hazards in a reactive way.
  - Following a disaster, we engage in
    - Search and rescue
    - Firefighting
    - Providing food, shelter, and medical care
  - This does reduce the loss of life and property
  - **BUT: to move to a higher level of hazard reduction will require increased efforts to anticipate disasters and their effects.**
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# Concept 5:

## Consequences of Hazards Can Be Minimized

- Reactive Response: Impact of and Recover from Disasters
    - The effect of a disaster upon a population may be either *direct* or *indirect*
      - Direct Effects:
        - People getting killed, injured, dislocated, or otherwise damaged
      - Indirect Effects:
        - Emotional distress, donation of money or goods, and the paying of taxes to pay for the recovery of property
    - Direct effects are felt by fewer individuals, whereas indirect effects affect many more people
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# Concept 5:

## Consequences of Hazards Can Be Minimized

- Stages of recovery following a disaster are
    - Emergency work
    - Restoration of Services and Communication Lines
    - Reconstruction
  - Life would be back to normal basically
  - **Reconstruction II:**
    - Planning is essential!!
    - Don't rush – evaluate how best to use recovery funds to rebuild to withstand future hazards
    - Rebuild to reduce damage and loss of life if another event should happen
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# **Concept 5:**

## **Consequences of Hazards Can Be Minimized**

- Anticipatory Response: Avoiding and Adjusting to Hazards
    - There is a need to minimize the effects of disasters by evaluating the perception of the hazards
    - People need to be educated to understand natural hazards and how they should deal with an event should they be involved in one.
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# **Concept 5:**

## **Consequences of Hazards Can Be Minimized**

- There are many ways which can be used to help reduce the consequences of natural hazards
    - 1. Careful planning for land-use**

Don't build on a flood plain
    - 2. Insurance**

Have flood or earthquake insurance
    - 3. Evacuation**

Have a plan if something happens
    - 4. Disaster Preparedness**

Training and organization
    - 5. Have an artificial control of Natural Processes**

Sometime they work, sometimes they don't
    - 6. Too often the option is to simply loss**
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# Many Hazards Provide a Natural Service Function

- Somewhat ironic;
  - Natural events which take human life and destroy property are often a benefit or natural service to nature
    - Periodic flooding supplies nutrients to the land it floods.
    - Forest fires will release new seeds to for new growth
      - Uintah Forest, eaten by a deadly beetle, waiting to burn, will get rid of the beetle and the dead trees, and begin re-growth
    - Landslides will dam up stream and make a lake for important water storage
    - If the dam breaks, then the land downstream is rejuvenated
    - The Hawaiian Islands are growing due to lava flow from the volcano eruptions
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# Global Climate Change and Hazards

- Global and Regional Climate Change
    - Could affect the incidence of hazardous natural events such as storms, landslides, drought, and fires.
  - How might this happen?
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